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(58) Field of Search
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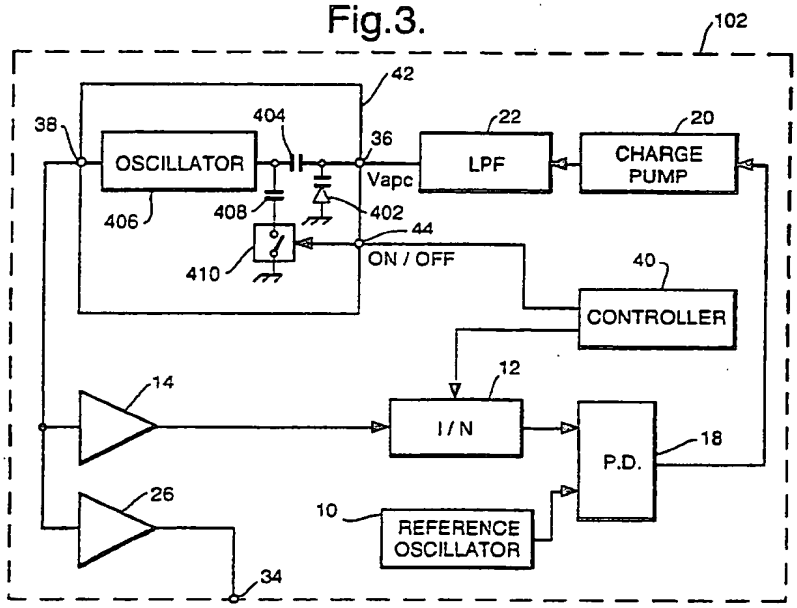
INT CL[5] H03C , H03J , H03L
Online databases: WPI, JAPIO

(54) **VCO; Frequency synthesizers**

(57) When a switch 410 is turned ON corresponding to a frequency required by a controller 40, a capacitor 408 constitutes a capacitance component of a VCO 42 and when the switch 410 is turned OFF correspondingly to a frequency required by the controller 40, the capacitor 408 is disconnected from the VCO. Thus, it is possible to oscillate over a wide band frequency even if change of oscillation frequency due to change of as control voltage is small, by changing the capacitance component of the VCO separately from the control using the control voltage. The VCO may be a part of a phase locked loop frequency synthesizer. Phase noise on the VCO output due to noise on the control voltage of the VCO is reduced by the present invention.

Fig.3.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.
(PRIOR ART)

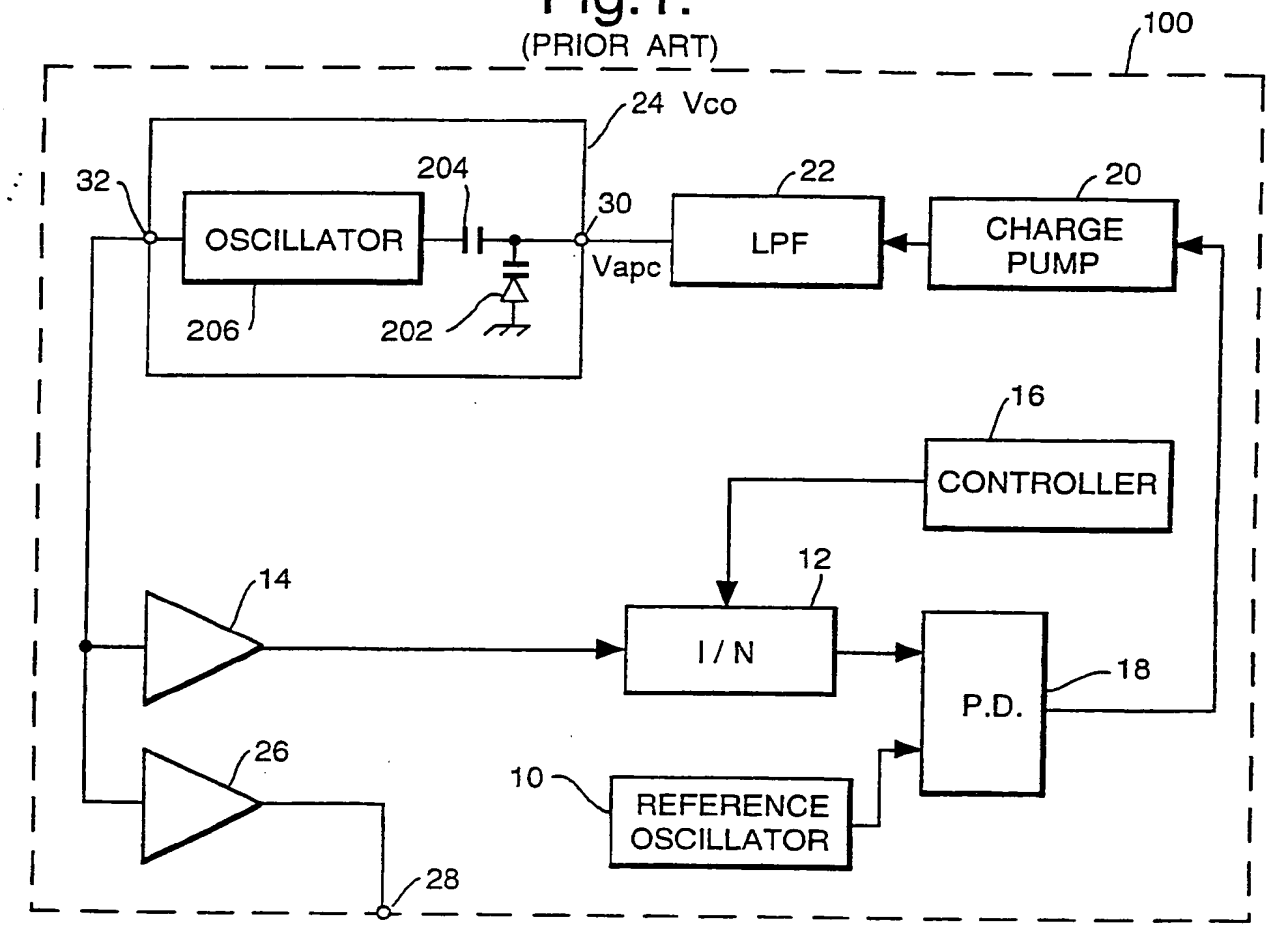


Fig.2.
(PRIOR ART)

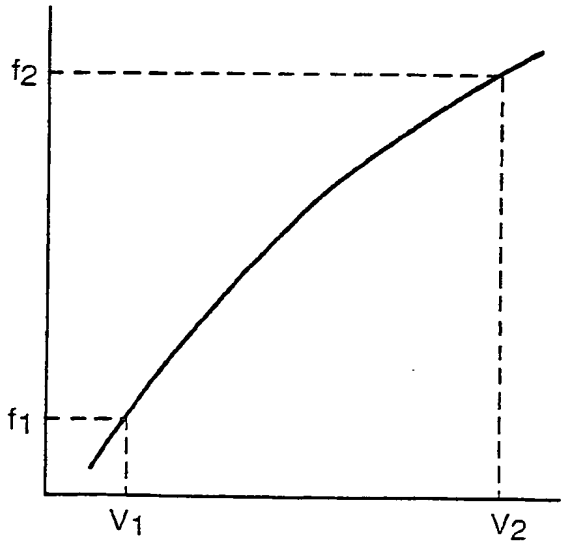


Fig.3.

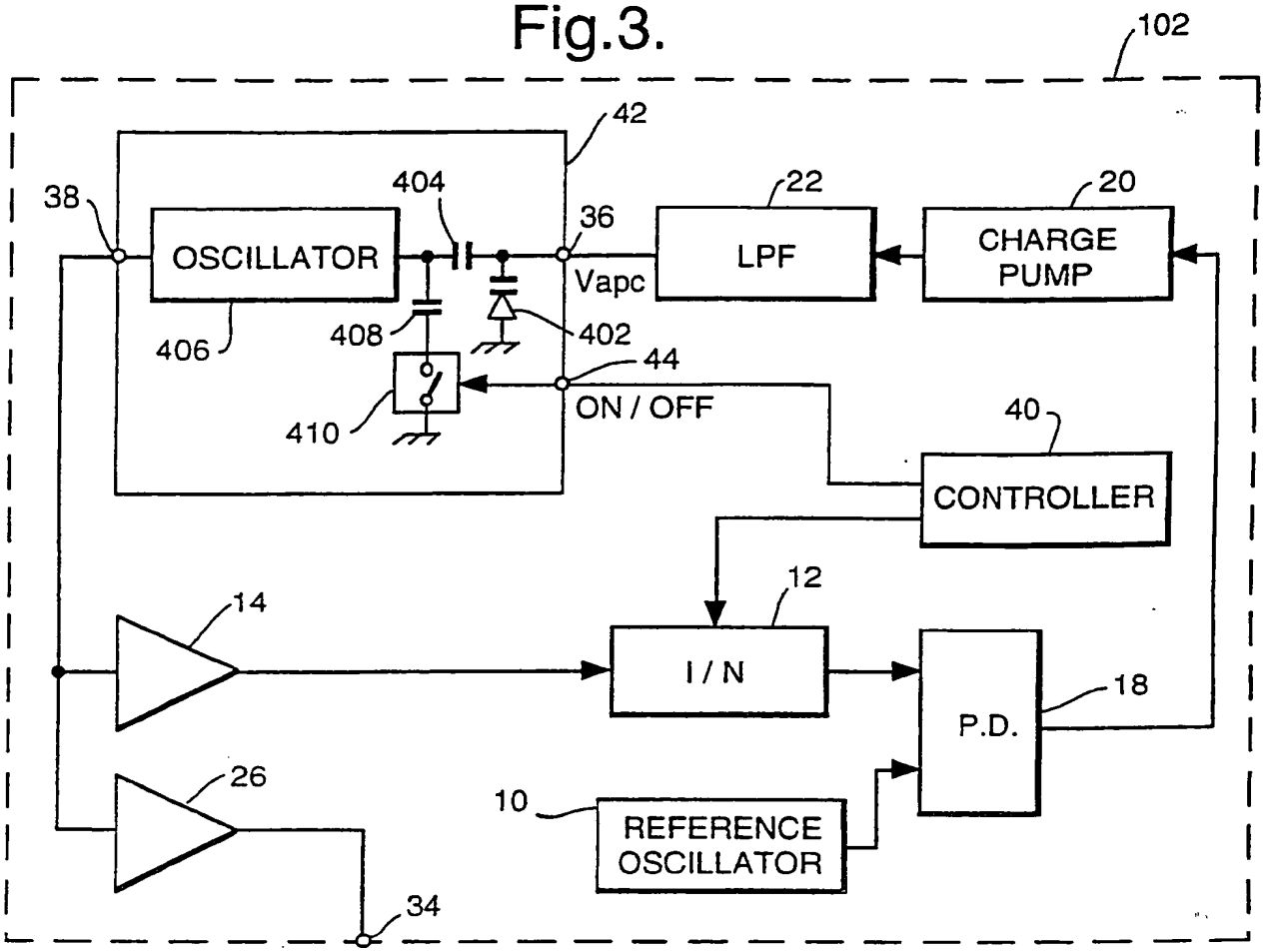
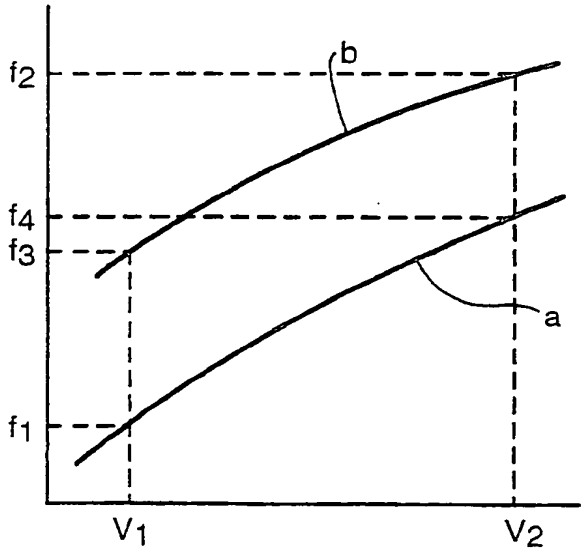

102
42
38
404
36
22
20
OSCILLATOR
LPF
CHARGE PUMP
Vapc
406
408
402
44
410
ON / OFF
40
CONTROLLER
14
12
I / N
P.D.
18
26
10
REFERENCE OSCILLATOR
34

Fig.4.


f2
b
f4
f3
a
f1
V1
V2

Frequency Synthesizer

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a frequency synthesizer and, more particularly, to a frequency synthesizer for use in a radio communication using digital modulation and demodulation.

Description of the Related Art

Recently, the frequency synthesizer which is capable of oscillating a wide frequency band is requested in a wide band radio device.

Since the oscillation frequency of a voltage control oscillator (VCO) of the conventional frequency synthesizer has a one to one correspondence to the control voltage, it is necessary, in order to make the oscillation frequency band wider, to make an inclination of the control voltage-oscillation frequency characteristics curve, that is, a modulation sensitivity, larger so that the oscillation frequency is changed largely with small change of the control voltage.

In the above-identified frequency synthesizer, however, since the modulation sensitivity is large, noise such as battery noise, switching noise, noise of a phase detector and so on from a control voltage line of the VCO is apt to appear in an output of the VCO as phase noise. As a result, the conventional frequency synthesizer suffers from a disadvantage for a radio

device using a digital modulation such as quaternary phase-shift keying (QPSK) or minimum shift keying (MSK).

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a frequency synthesizer capable of reducing the phase noise of the output of the VCO due to noise from the control line of a VCO while maintaining a wide frequency band.

According to the present invention, the inventive frequency synthesizer includes a voltage controlled oscillator for oscillating at a variable frequency by changing a reactance component thereof in response to a control voltage applied thereto and reactance changing means for changing a reactance component of the voltage controlled oscillator separately from the reactance change caused by the control voltage.

According to the present invention, another inventive frequency synthesizer includes a means for oscillating a first frequency signal having a first continuous control voltage-oscillated frequency characteristic curve within a first frequency range in response to a selected control voltage variation, said first frequency range being between a first frequency and a second frequency greater than said first frequency, and a means for oscillating a second frequency signal having a second continuous control voltage-oscillated frequency characteristic curve within a second frequency range different from said first frequency range in response to said selected control voltage variation, said second frequency range being between a third frequency and a fourth frequency greater than

said third frequency, whereby, there is produced control voltage-oscillated frequency characteristic curves each having an inclination less than the inclination of a third frequency signal having a continuous control voltage-oscillated frequency characteristic curve between said first and fourth frequency to thereby reduce output phase noise of said frequency synthesizer.

The frequency synthesizer according to the present invention oscillates over a wide band frequency even if oscillation frequency change due to change of the control voltage is small, by changing the capacitance component of the voltage controlled oscillator by means of the capacitance changing means.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of this invention will become more apparent from the following detailed description taken with the accompanying drawings in which:

Fig. 1 is a block diagram of a conventional frequency synthesizer;

Fig. 2 is a graph showing a control voltage-oscillation frequency characteristics of the VCO shown in Fig. 1;

Fig. 3 is a block diagram of a preferred embodiment of a frequency synthesizer according to the present invention; and

Fig. 4 is a graph showing a control voltage-oscillation frequency characteristics of the VCO shown in Fig. 3.

In the drawings, the same reference numerals denote the same structural elements.

DESCRIPTION OF THE PREFERRED EMBODIMENT

First, to facilitate an understanding of the present invention, a conventional frequency synthesizer will be described with reference to Figs. 1 and 2.

In Fig. 1, a reference oscillator 10 in a frequency synthesizer 100 produces a reference signal. A frequency divider (1/N) 12 divides the frequency of a signal from a buffer amplifier 14 by the frequency dividing number N determined by a controller 16 on the basis of a required frequency. A phase detector (P.D.) 18 compares, in phase, the signal from the reference oscillator 10 with the signal from the frequency divider 12 and outputs a result of comparison. A charge pump 20 converts an amount of advance/delay of phase into a voltage on the basis of the output signal of the phase detector 18. A low-pass filter (LPF) 22 removes a.c. components of the voltage from the charge pump 20. A voltage controller oscillator (VCO) 24 produces a signal having a frequency corresponding to a control voltage from the LPF 22 through an input terminal 30 and supplies the signal from an output terminal 32 to buffer amplifiers 14 and 26 for amplifying the signal from the VCO 24. A signal from the buffer amplifier 26 is supplied from an output terminal 28 of the frequency synthesizer 100.

The VCO 24 consists of a variable capacitance diode 202, a capacitor 204 and an oscillator 206. A capacitance of the variable capacitance diode 202 is changed correspondingly to the control voltage applied to the input terminal 30 to thereby change the oscillation frequency.

Fig. 2 is a graph showing a control voltage-oscillation frequency characteristics of the VCO 24 shown in Fig. 1.

In Fig. 2, the control voltage applied to the terminal 30 is put on an abscissa and the oscillation frequency of the signal output from the output terminal 32 is put on an ordinate. As shown in Fig. 2, when the control voltage is changed from V1 to V2, the oscillation frequency is changed from f1 to f2.

As mentioned above, however, since the modulation sensitivity is large, noise such as battery noise, switching noise of the charge pump, or noise of the phase detector from the control voltage line of the VCO influences the output of the VCO as phase noise.

Now there will be described in detail preferred embodiments of the present invention with reference to Figs. 3 and 4.

Fig. 3 is a block diagram schematically showing a preferred embodiment of a frequency synthesizer according to the present invention. In Fig. 3, the frequency synthesizer 102 consists of a reference oscillator 10, a frequency divider (1/N) 12, buffer amplifiers 14 and 26, a phase detector (P.D.) 18, a charge pump 20, a low-pass filter (LPF) 22, a controller 40 and a voltage controller oscillator (VCO) 42.

In Fig. 3, the reference oscillator 10 in the frequency synthesizer 102 produces a reference signal. The frequency divider (1/N) 12 divides frequency of a signal from the buffer amplifier 14 by the frequency dividing number N determined by the controller 40 on the basis of a required frequency. The phase detector (P.D.) 18 compares, in phase, the signal from the reference oscillator 10 with a divided signal from the frequency divider 12 and outputs a result of comparison. The charge pump 20, which operates as a converter, converts an amount of

advance/delay of phase into a voltage on the basis of the output signal of the phase detector 18. The LPF 22 removes a.c. components of the voltage from the charge pump 20. The VCO 42 produces a signal having a frequency corresponding to a control voltage from the LPF 22 through an input terminal 36 and supplies the signal from an output terminal 38 to the buffer amplifiers 14 and 26 for amplifying the signal from the VCO 42. A signal from the buffer amplifier 26 is supplied from an output terminal 34 of the frequency synthesizer 102. These functions are the same as those of the conventional frequency synthesizer shown in Fig. 1.

The VCO 42 consists of a variable capacitance diode 402, capacitors 404 and 408, an oscillator 406 and a switch 410. The capacitor 404 and variable capacitance diode 402 construct capacitance varying means. One side of the capacitor 408 is connected to a junction between the oscillator 406 and the capacitor 404. The other side of the capacitor 408 is connected to one side of the switch 410 whose other end is connected to the ground. A capacitance of the variable capacitance diode 402 is changed correspondingly to the control voltage applied to the input terminal 36 to thereby change the oscillation frequency.

The controller 40 controls the ON-OFF of the switch 410 in the VCO 42 on the basis of the required frequency.

Fig. 4 is a graph showing a control voltage-oscillation frequency characteristics of the VCO 42 shown in Fig. 3.

In Fig. 4, the control voltage applied to the input terminal 36 is put on an abscissa and the oscillation frequency of the signal output from the output terminal 38 is put on an ordinate.

A curve (a) shows the characteristics when the switch 410 is ON and a curve (b) shows the characteristics when the switch 410 is OFF.

When the switch 410 is turned ON through a terminal 44 correspondingly to a frequency required by the controller 40, oscillation frequency required of the VCO 42 is changed from f1 to f4 in response to the change V1 to V2 of the control voltage as shown by the curve (a) in Fig. 4. When the switch 410 is turned OFF through the terminal 44 correspondingly to a frequency required by the controller 40, the oscillation frequency is changed from f3 to f2 in response to the change V1 to V2 of the control voltage as shown by the curve (b) in Fig. 4. The inclination of each curve is smaller compared with that of the conventional frequency synthesizer so as to avoid the phase noise.

That is, in this embodiment, a total capacitance component of the VCO 42 is changed in dependence on whether the switch 410 is ON or OFF so that the single frequency synthesizer has two kinds of control voltage-oscillation frequency characteristics with which the frequency band from f1 to f2 is covered.

Although, in this embodiment, the capacitor 408 is connected between the oscillator 406 and the capacitor 404, the present invention is not limited to this construction, provided that the total capacitance component of the VCO 42 can be changed by ON/OFF switching of the switch 410.

Further, although in this embodiment a single capacitor which is disconnected from the circuit when the switch is turned OFF is provided, it is possible in the present invention to

provide at least two sets of such switches and capacitors so that there are at least three kinds of control voltage-oscillation frequency characteristics provided. The larger the number of the kinds of control voltage-oscillation frequency characteristics provides the smaller the inclination of the individual control voltage-oscillation frequency characteristics.

Further, the switch 410 may be a mechanical switch or an electronic switch.

As described hereinbefore, since, according to the present invention, it is possible to set a plurality of oscillation frequencies for the same control voltage by shifting the oscillation frequency of the VCO in dependence on ON/OFF state of the switch within the VCO, it is possible to set the inclination of the control voltage-oscillation frequency characteristics curve of the VCO, that is, the modulation sensitivity, smaller compared with the conventional frequency synthesizer in which all of required frequency band is covered by a single control voltage-oscillation frequency and it is possible to reduce the possibility of phase noise in an output of the VCO caused by noise indirectly introduce from the control voltage line of the VCO.

As mentioned, according to the present invention, since it is possible to reduce phase noise of the output of the frequency synthesizer, the frequency synthesizer becomes optimal for a radio device utilizing a digital modulation such as QPSK or MSK.

Although the embodiment has been described with respect to a case in which the modification was based on a specific factor,

it goes without saying that the present invention is not restricted to this case.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The appended abstract as filed herewith is included in the specification by reference.

What is claimed is:

CLAIMS

1. A frequency synthesizer comprising:

a voltage controlled oscillator for oscillating at a variable frequency by changing a reactance component thereof in response to a control voltage applied thereto; and

reactance changing means for changing a reactance component of said voltage controlled oscillator separately from said reactance change caused by said control voltage.

2. The frequency synthesizer as claimed in claim 1, wherein said reactance changing means comprises:

a capacitor constituting a part of said reactance component of said voltage controlled oscillator;

a switch for connecting said capacitor constituting said part of said reactance component of said voltage controlled oscillator when it is in a first state and disconnecting said capacitor from said voltage controlled oscillator when it is in a second state; and

a switch controller for controlling said switch in said first and second states.

3. The frequency synthesizer as claimed in claim 1, further comprising:

a reference oscillator for oscillating a reference signal;

a frequency divider for dividing frequency of an output signal from said voltage controlled oscillator and supplying a divided signal;

a phase detector, coupled to said reference oscillator and said frequency divider, for detecting a phase difference between said reference signal and said divided signal; and

a charge pump, coupled to said phase detector, for changing said phase difference to said control voltage.

4. A frequency synthesizer comprising:

an oscillator for oscillating a signal corresponding to a control voltage;

a reference oscillator for oscillating a reference signal;

a phase detector for detecting a phase difference between said signal and said reference signal;

a converter for converting said phase difference to said control voltage;

reactance varying means for varying a reactance component thereof in response to said control voltage and varying an oscillating frequency of said signal of said oscillator; and

reactance changing means for changing said reactance component separately from a reactance variation of said control voltage.

5. The frequency synthesizer as claimed in claim 4, further comprising a controller for controlling connection of said reactance changing means to said oscillator and said reactance varying means and to disconnect said reactance changing means from said oscillator and said reactance varying means.

6. The frequency synthesizer as claimed in claim 4, wherein said reactance changing means comprises:

a capacitor connected a junction between said oscillator and said reactance varying means; and

a switch controlled by said controller.

7. A voltage controlled oscillator comprising:

a first capacitor;

a diode, connected to said first capacitor and a ground, for changing a capacitance therein by a control voltage;

a second capacitor;

a switch, connected to said second capacitor and the ground, for connecting said second capacitor to said first capacitor and disconnecting said second capacitor from said first capacitor, corresponding to a control signal of a controller; and

an oscillator, connected to a junction of said first and second capacitors, for oscillating a signal having an oscillating frequency.

8. A frequency synthesizer for generating a frequency signal variable between two frequencies comprising:

first means for oscillating a first frequency signal having a first continuous control voltage-oscillated frequency characteristic curve within a first frequency range in response to a selected control voltage variation, said first frequency range being between a first frequency and a second frequency greater than said first frequency; and

second means for oscillating a second frequency signal having a second continuous control voltage-oscillated frequency characteristic curve within a second frequency range different from said first frequency range in response to said selected control voltage variation, said second frequency range being between a third frequency and a fourth frequency greater than said third frequency;

whereby, there is produced control voltage-oscillated frequency characteristic curves each having an inclination less than the inclination of a third frequency signal having a continuous control voltage-oscillated frequency characteristic curve between said first and fourth frequency to thereby reduce output phase noise of said frequency synthesizer.

9. A method for controlling a frequency synthesizer, the method comprising the steps of:

oscillating a signal corresponding to a control voltage;

oscillating a reference signal;

detecting a phase difference between said signal and said reference signal;

converting said phase difference to said control voltage;

varying a reactance component in response to said control voltage;

varying an oscillating frequency of said signal corresponding to said reactance component; and

changing said reactance component separately from a reactance variation of said control voltage.

10. A method for controlling a frequency synthesizer for generating a frequency signal variable between two frequencies, the method comprising the steps of:

oscillating a first frequency signal having a first continuous control voltage-oscillated frequency characteristic curve within a first frequency range in response to a selected control voltage variation, said first frequency range being between a first frequency and a second frequency greater than said first frequency; and

oscillating a second frequency signal having a second continuous control voltage-oscillated frequency characteristic curve within a second frequency range different from said first frequency range in response to said selected control voltage variation, said second frequency range being between a third frequency and a fourth frequency greater than said third frequency, whereby, there is produced control voltage-oscillated frequency characteristic curves each having an inclination less than the inclination of a third frequency signal having a continuous control voltage-oscillated frequency characteristic curve between said first and fourth frequency to thereby reduce output phase noise of said frequency synthesizer.

11. A frequency synthesizer or a method of controlling a frequency synthesizer substantially as hereinbefore described with reference to Figures 3 and 4 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

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Application number
GB 9416381.3

Relevant Technical Fields

(i) UK Cl (Ed.M) H3A: AQA, AQX, AXB, AXC, AXD, AXF, AXX; H3Q: QBES, QBET; H3R: RFMA

(ii) Int Cl (Ed.5) H03C, H03J, H03L

Search Examiner
MR S SATKURUNATH

Date of completion of Search
13 DECEMBER 1994

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) WPI, JAPIO

Documents considered relevant following a search in respect of Claims :-
1-7,9,11

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2120478 A	(STC) see especially Figures 1 and 2	1-6 and 9
X	EP 0072593 A1	(TELECOM) see especially Figure 1	1,3,4, and 9
X	WO 85/00942 A1	(MOTOROLA) see especially Figures 4 and 6	1,3,4, and 9

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